Wrist Anatomy and Biomechanics Revisited: The Absolute Location of the Ulnar Styloid Process, the Direction of Distal Ulnar Curvature, and Three-Dimensional Ulnolunate Distance During Forearm Rotation

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1. Where Is the Ulnar Styloid Process? - The Absolute Location of the Ulnar Styloid Process and a New Verification Method of Forearm Rotation on Wrist Lateral Radiographs

**Background:** The location of the ulnar styloid process can be confusing when the forearm is not in neutral rotation, because the radius and the hand rotate around the ulna. The purpose of this study was to identify the absolute location of the ulnar styloid process which is independent of pronation or supination, and use it as a reference for neutral forearm rotation on wrist lateral radiographs.

**Methods:** Forearm CT images of 23 patients taken with elbow flexion of 70° to 90° were analyzed. Axial images of the CT were reconstructed to be perpendicular to the distal ulnar shaft. The absolute location of the ulnar styloid process in this study was defined as the position of the ulnar styloid process on the axial plane of the ulnar head relative to the long axis of the humeral shaft, with the elbow set in the position for standard wrist lateral radiographs. To identify in which direction the ulnar styloid is located on the axial plane of the ulnar head, the angle between ‘the line of humeral long axis projected on the axial plane of the ulna’ and ‘the line passing the center of the ulnar head and the center of the ulnar styloid’ was measured (“ulnar styloid direction angle”). To identify how volarly or dorsally the ulnar styloid should appear on wrist true lateral views, the ratio of ‘the volar-dorsal diameter of the ulnar head’ and ‘the distance between the volar-most plain of the ulnar head and the center of the ulnar styloid’ was calculated (“ulnar styloid location ratio”).

Results: The mean ulnar styloid direction angle was 12° dorsally. The mean ulnar styloid location ratio was 1:0.55.

**Conclusions:** The ulnar styloid is located at nearly ulnar-most (the opposite side of the humerus with the elbow flexed) and slightly dorsal aspect of the ulnar head on axial plane. It should appear almost midway (55% dorsally) from the ulnar head on standard wrist lateral view with neutral forearm rotation. These standard locations could help clinicians determine whether the forearm is neutral or
rotated on an axial wrist CT/MR scan or a wrist lateral radiograph.

2. Validation of wrist PA/AP radiographs - a new method using the distal ulnar curvature as the reference of forearm rotation

**Background:** Although standard wrist PA/AP radiographs should be obtained with neutral forearm rotation, there have been no reports on how we can validate the forearm rotation in radiographs already taken.

**Methods:** The standard wrist PA view is obtained with the shoulder abducted 90° from the trunk and the elbow flexed at 90° with the ulna perpendicular to the humerus. The forearm should be in neutral rotation, and the wrist should be with no flexion, extension or deviation. As the radius rotates around the ulna during pronation/supination, we hypothesized that if the distal ulna has a specific curvature we can find out whether a wrist PA or AP view is obtained with the forearm in neutral or in pronation/supination. We found forearm 3D CT images of 23 patients with non-ulnar disorder, which were taken with the elbow flexed more than 70°. The distal ulnar curvature in relation to the humeral shaft was evaluated.

**Results:** The distal ulna had a curvature which is dorsally (laterally in relation to the humeral shaft) concave. In a wrist PA/AP radiograph which is taken with neutral forearm rotation, the distal ulnar shaft appears almost straight. In a wrist PA/AP radiograph which is taken with the forearm pronated, the distal ulnar shaft appears radially curved (convex to the radius). In a wrist PA/AP radiograph which is taken with the forearm supinated, the distal ulnar shaft appears counter-radially curved (concave to the radius).

**Conclusions:** Our results enable the validation of forearm rotation in wrist lateral views already taken. This is helpful for measurements and comparisons of wrist parameters, especially for the ulnar variance which varies with forearm rotation.

3. Translation of the ulnar head is more important than ulnar variance change for three-dimensional ulnolunate distance change during forearm rotation

**Background:** Ulnolunate distance (ULD) is the principal parameter of ulnar impaction syndrome. Traditionally, the ulnolunate abutment has been thought to be aggravated by forearm pronation because of the increase in ulnar variance (UV). We hypothesized that in three-dimensional (3D) space, the ULD might be greater in pronation because the ulnar head is dorsally translated.
Materials and Methods: Twenty-one three-dimensional reconstructions of computed tomographies (CTs) of wrists taken in supination and pronation were used. ULD was measured in each position, and ULD change from supination to pronation was calculated. UV change from supination to pronation and the amount of translation of the ulnar head (TUH) from supination to pronation were measured directly by superimposing reconstructions of the supinated wrist and the pronated wrist.

Results: The mean ULD in pronation was significantly greater than that in supination (p = 0.009). The mean ULD change from supination to pronation was 0.4 ± 0.6 mm. The mean UV change from supination to pronation was 0.03 ± 0.6 mm. The mean amount of TUH from supination to pronation was 4.0 ± 2.2 mm. There was no significant correlation between the ULD change and the UV change. The ULD change had a significant positive linear relationship with the amount of TUH (Pearson’s correlation coefficient = 0.525, p = 0.014).

Conclusions: ULD change during forearm rotation is determined by the amount of TUH rather than by UV change. It may suggest that the TUH is a physiological mechanism which prevents ulnolunate impingement during pronation.